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Supercomputing
Center**

Centro Nacional de Supercomputación



EXCELENCIA
SEVERO
OCHOA

Impact of resolution and initialisation in climate seasonal predictions

F.J. Doblas Reyes

What

Environmental forecasting

Why

Our strength ...

- ... research ...
- ... operations ...
- ... services ...
- ... high resolution ...

How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models

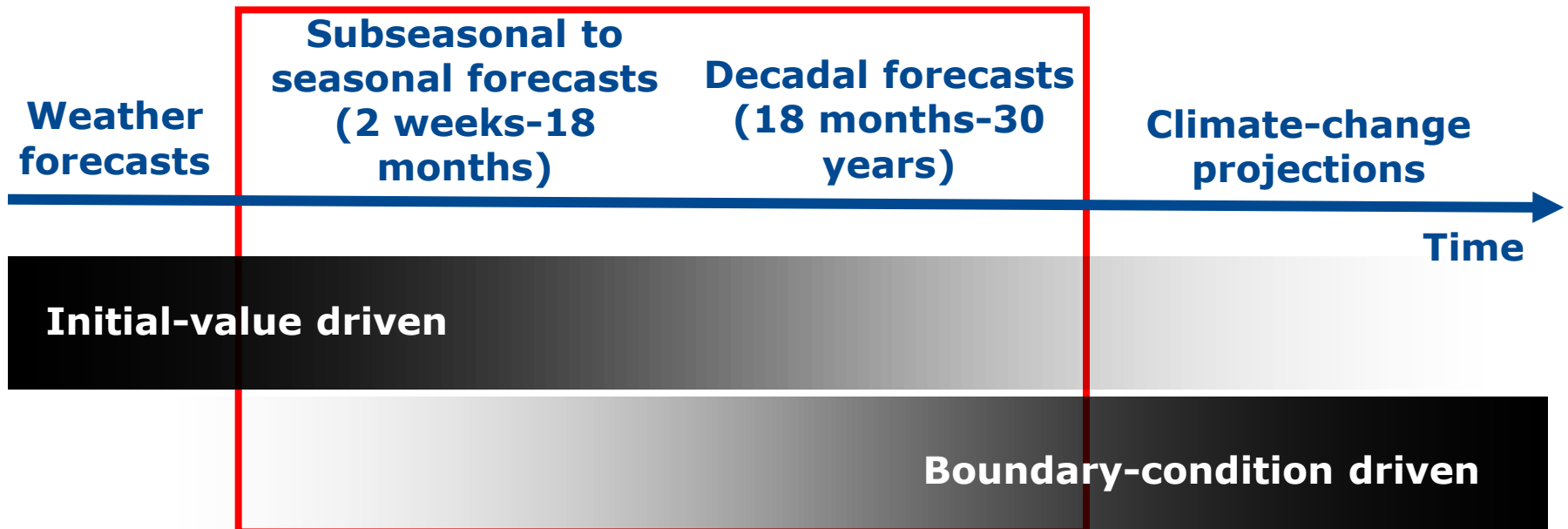
Earth system
services

Climate
prediction

Atmospheric
composition

Computational
Earth sciences

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (**sub-seasonal, seasonal and decadal**) in the middle. Prediction involves initialization and systematic comparison with a **simultaneous** reference.

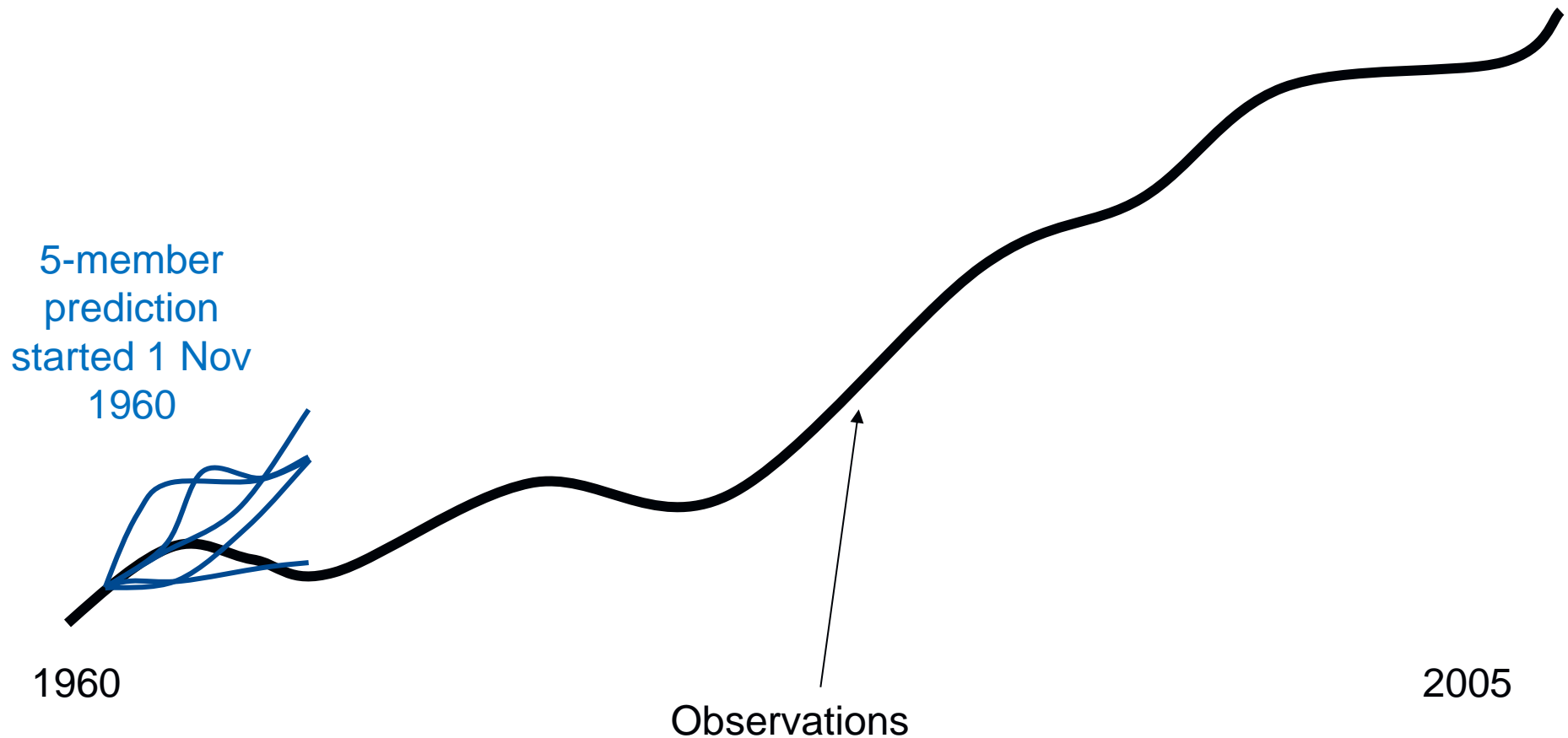


- Why initialising a climate model? To address the internal variability uncertainty and make a skilful forecast, one of the requirement is an accurate knowledge of the initial state of the system.
- Steps to initialise an ensemble climate forecast system:
 - make the most of the available observations to rebuild the best estimate of the system state (reanalysis).
 - transfer such information to the model avoiding imbalances, i.e. initialise the climate prediction system
 - run the ensemble with initial perturbations to account for the initial-state uncertainty

Climate prediction experiments



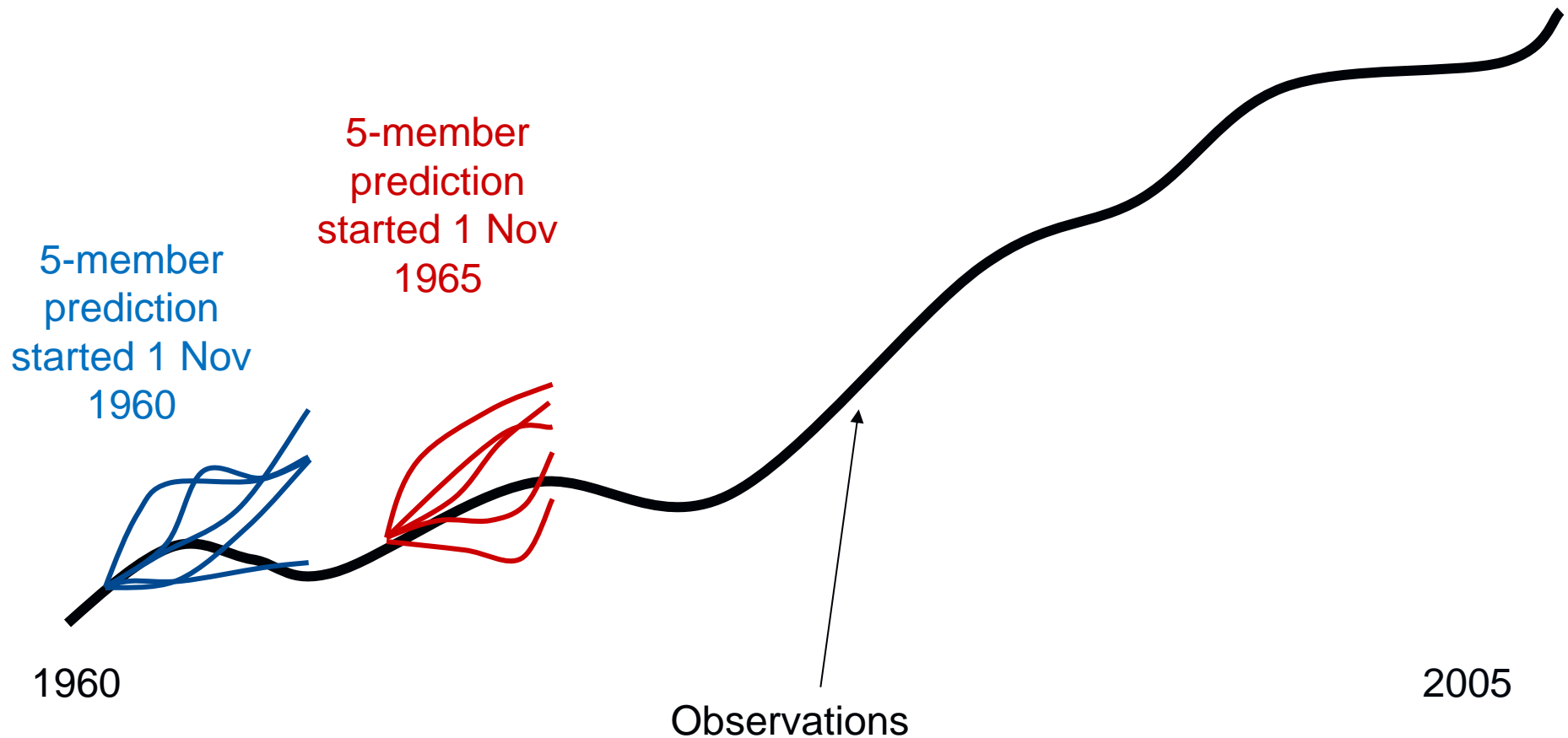
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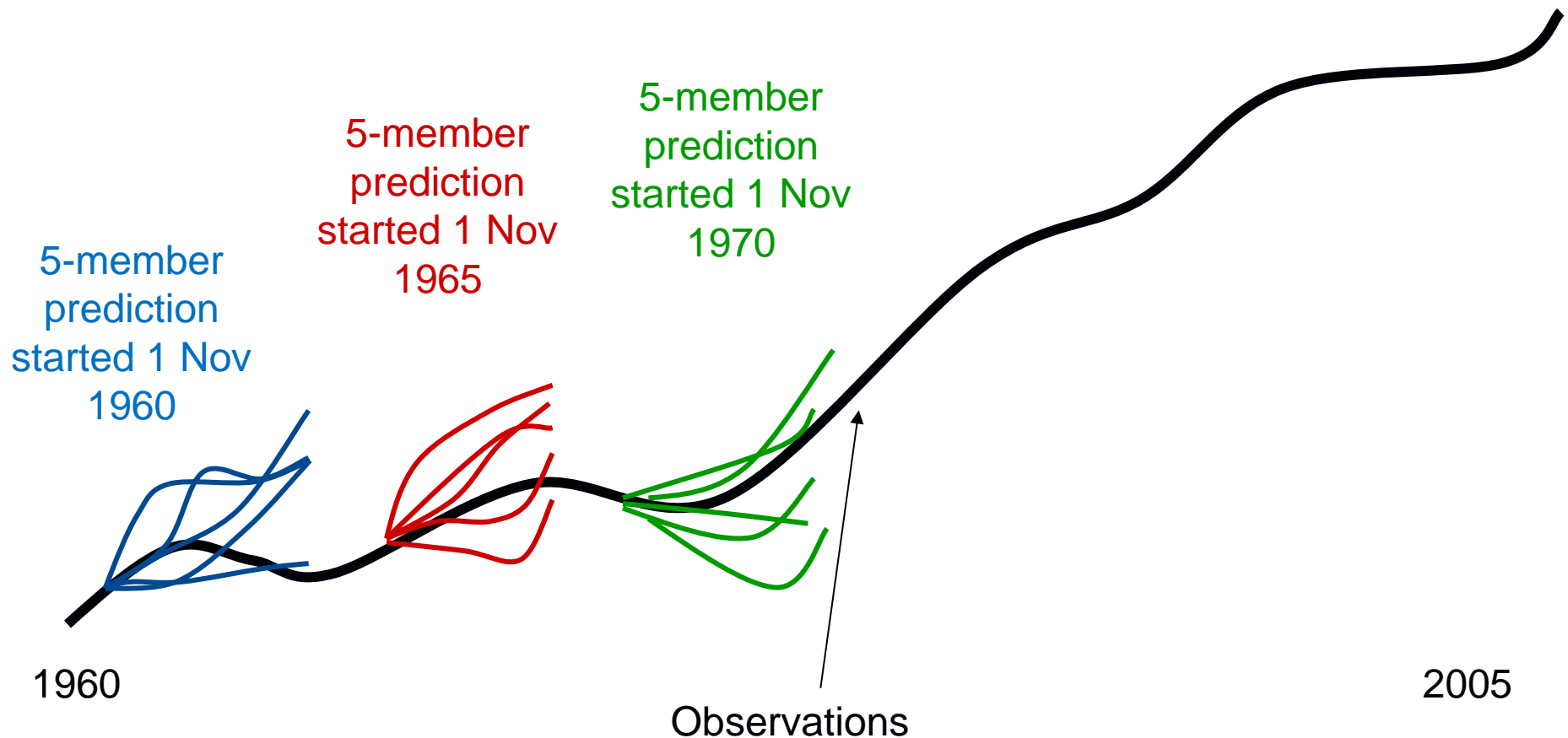
Climate prediction experiments



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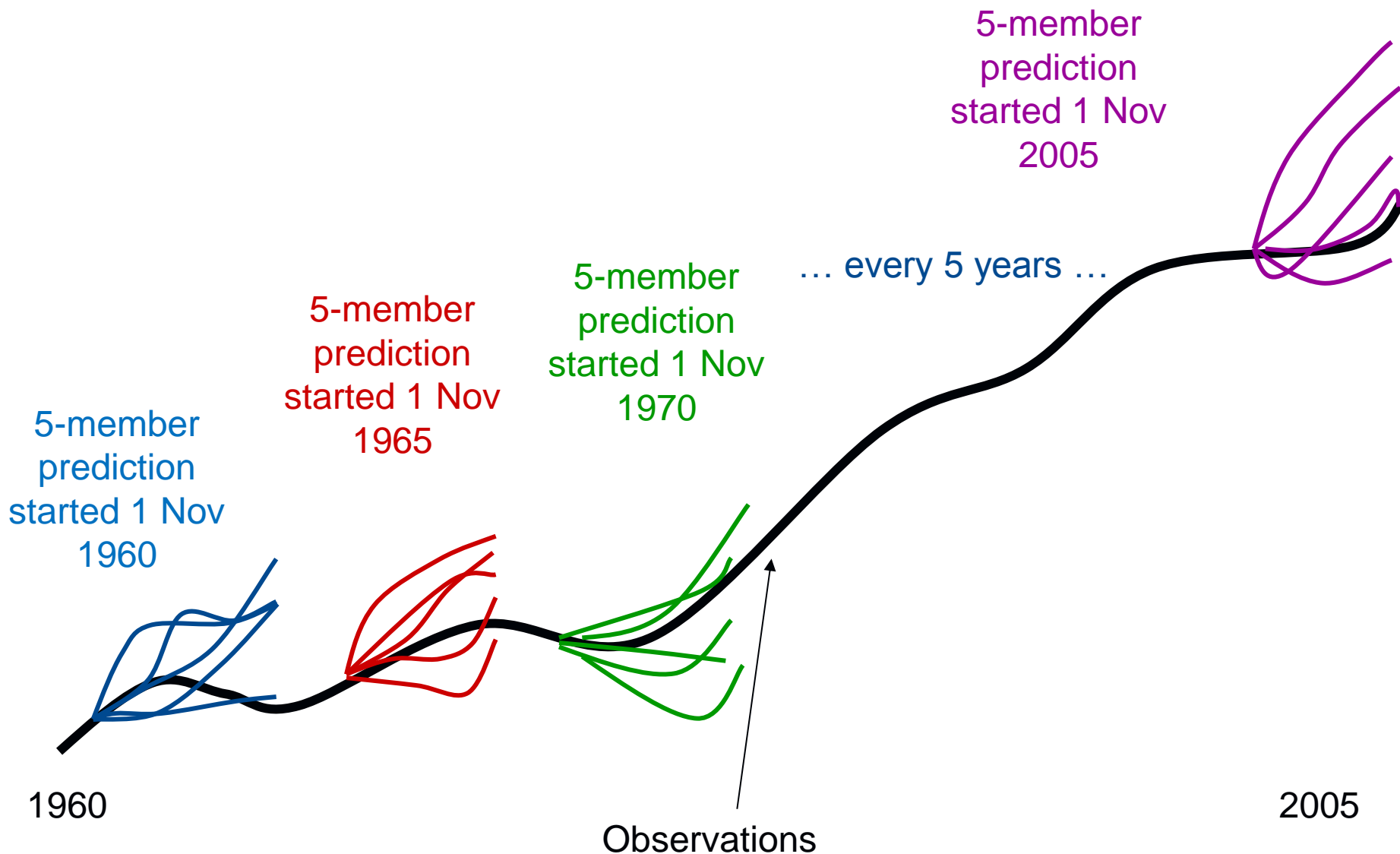
Climate prediction experiments



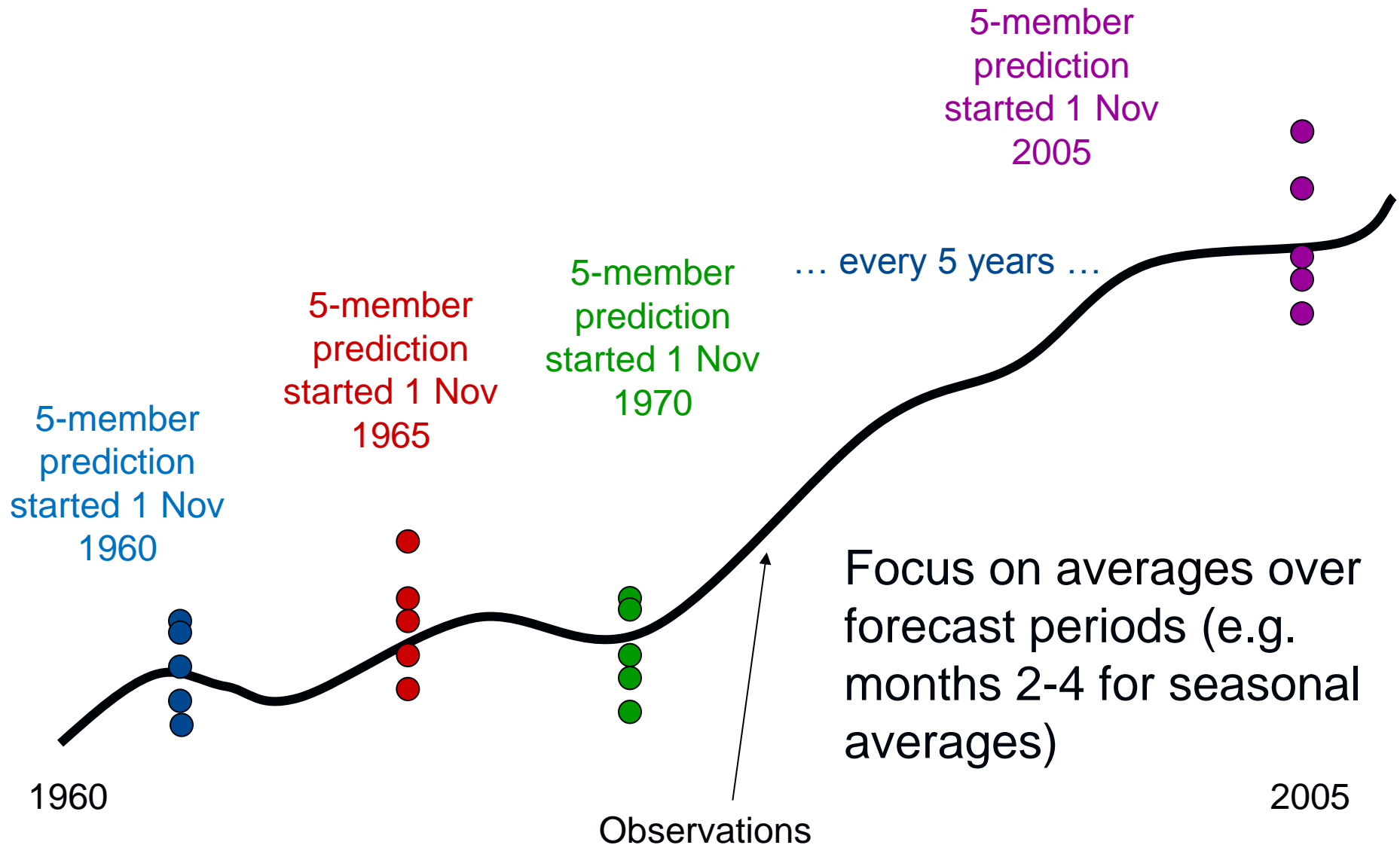
Climate prediction experiments



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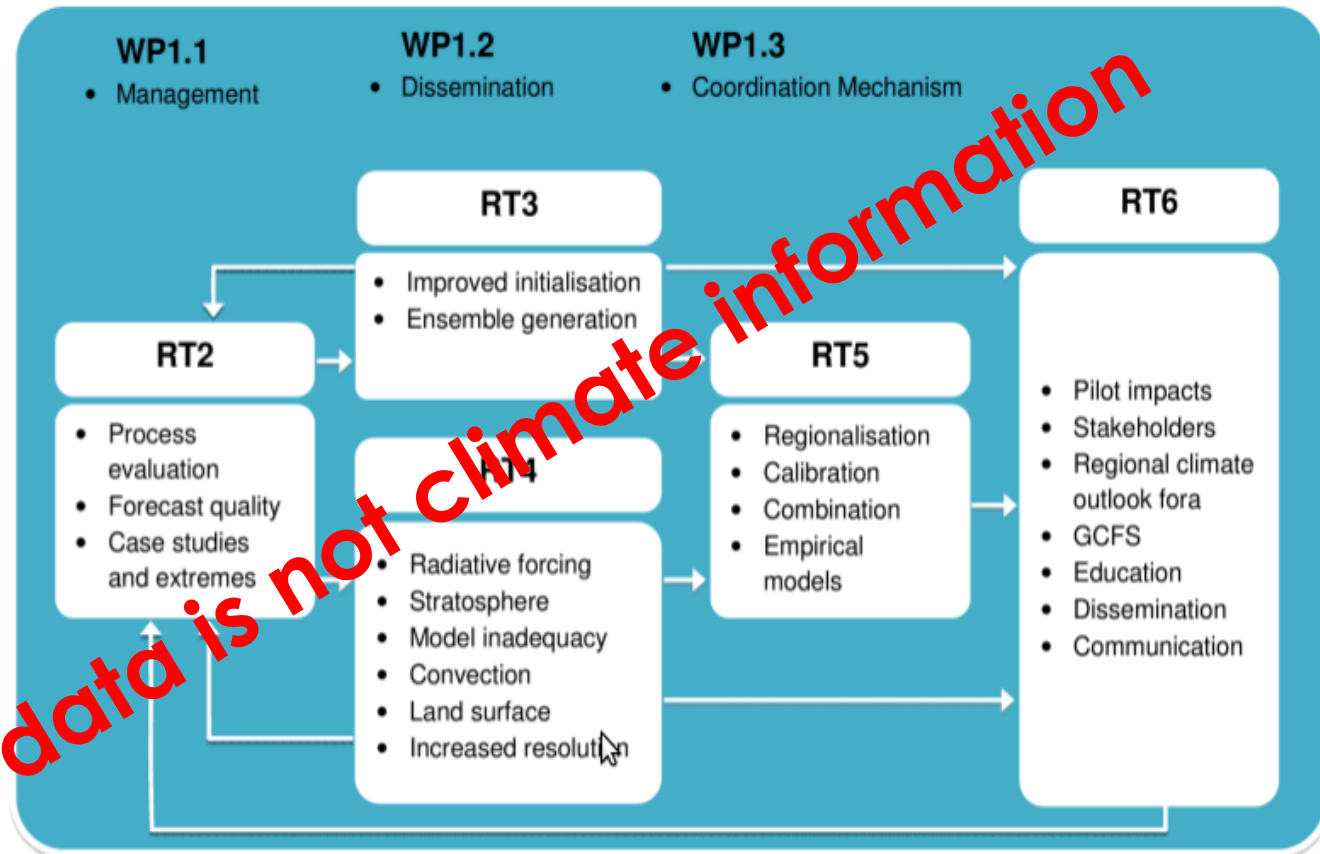
Climate prediction experiments



Climate prediction in Europe



Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniK
UM	UKMET



WP1.1: Management

WP1.2: Dissemination

WP1.3: Coordination across EUPORIAS, NACLIM & SPECS

RT2: Evaluation of current s2d forecast systems

RT3: Forecast strategies

RT4: Improved systems

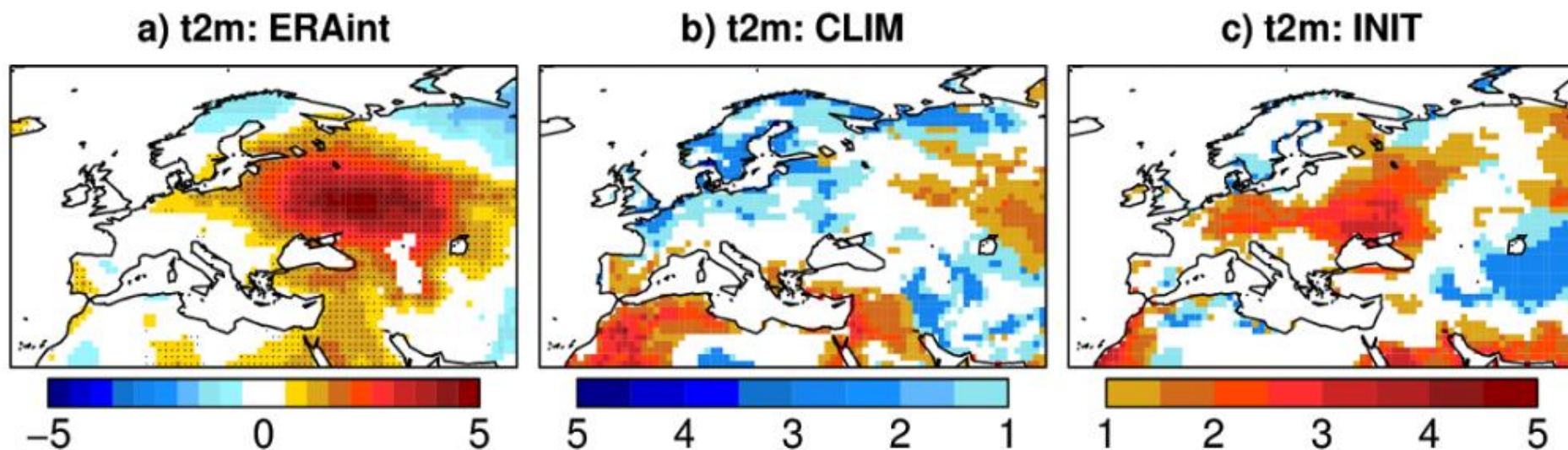
RT5: Calibrated predictions at the local scale

SPECS

JJA near-surface temperature anomalies in 2010 from ERAInt (left) and experiments with a climatological (centre) and a realistic (right) land-surface initialisation.

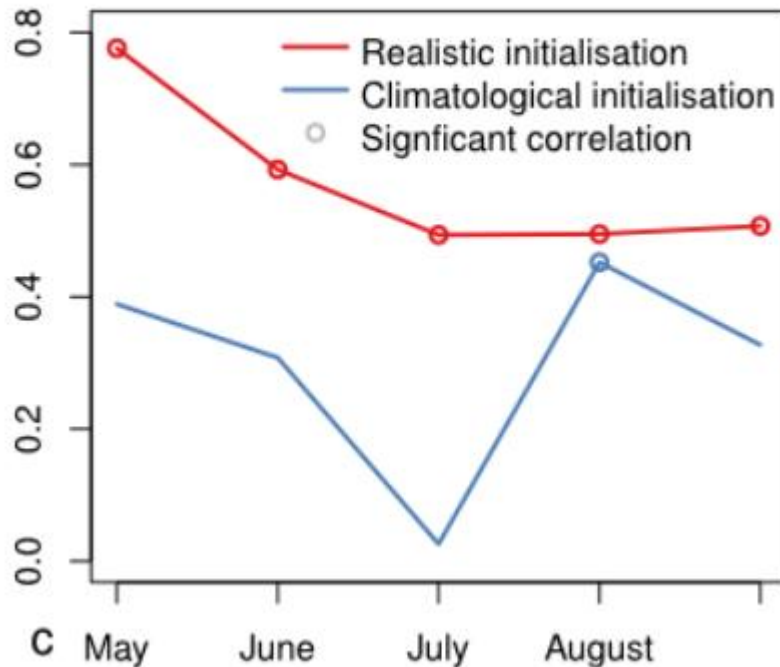
Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.

Similar results found for EC-Earth3 and high resolution (25 km).

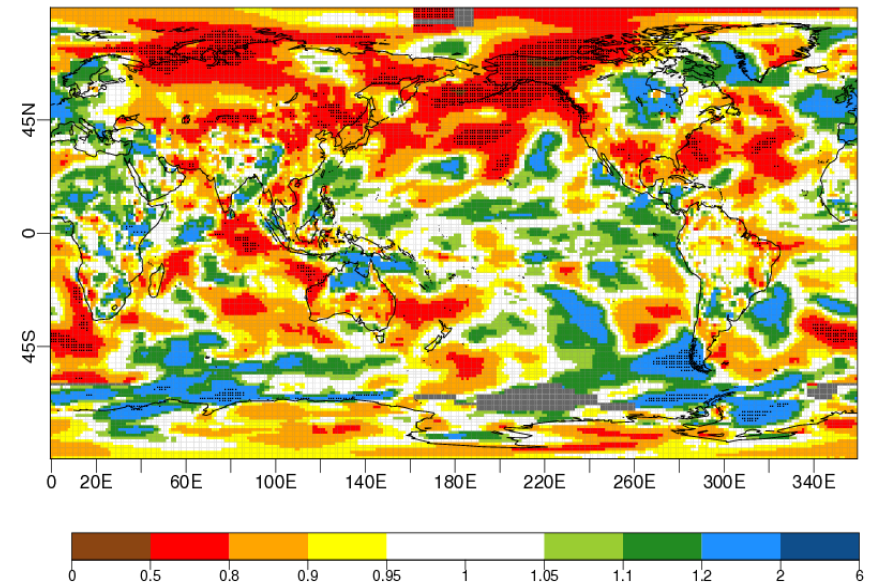


Predictions with EC-Earth started every May (left) and November (right) over 1993-2009 (left) and 1979-2010 (right) with ERAInt and ORAS4 initial conditions, and internal sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions.

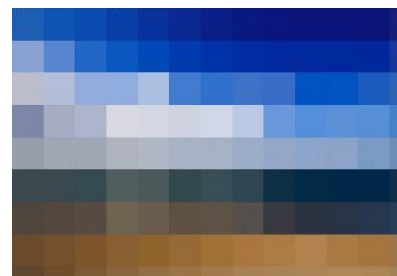
Arctic sea-ice area



Ratio RMSE Init/Clim hindcasts 2-metre temperature (months 2-4)

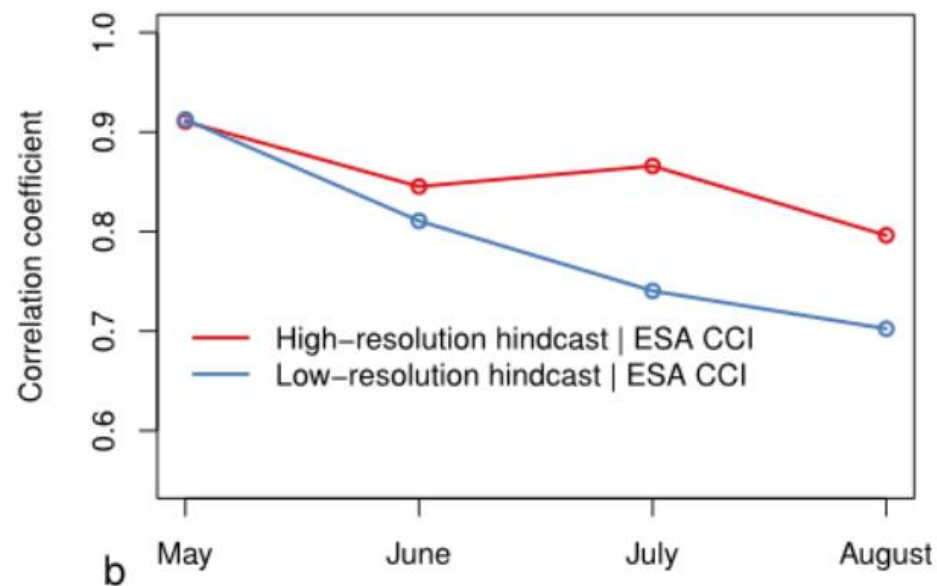
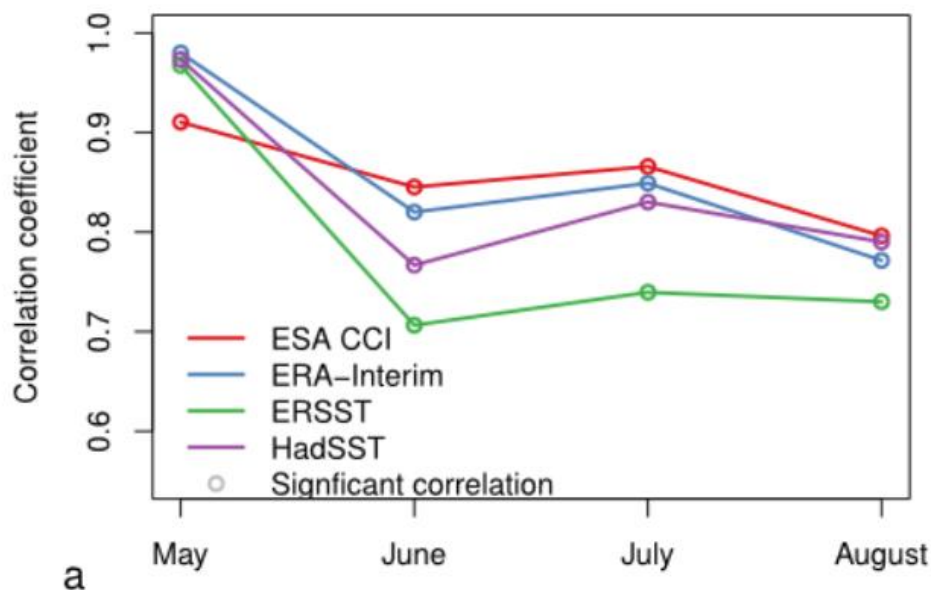


Predictions with EC-Earth3 started every May over 1993-2009 with ERAInt and GLORYS2v1 initial conditions, and IC3's sea-ice reconstruction.



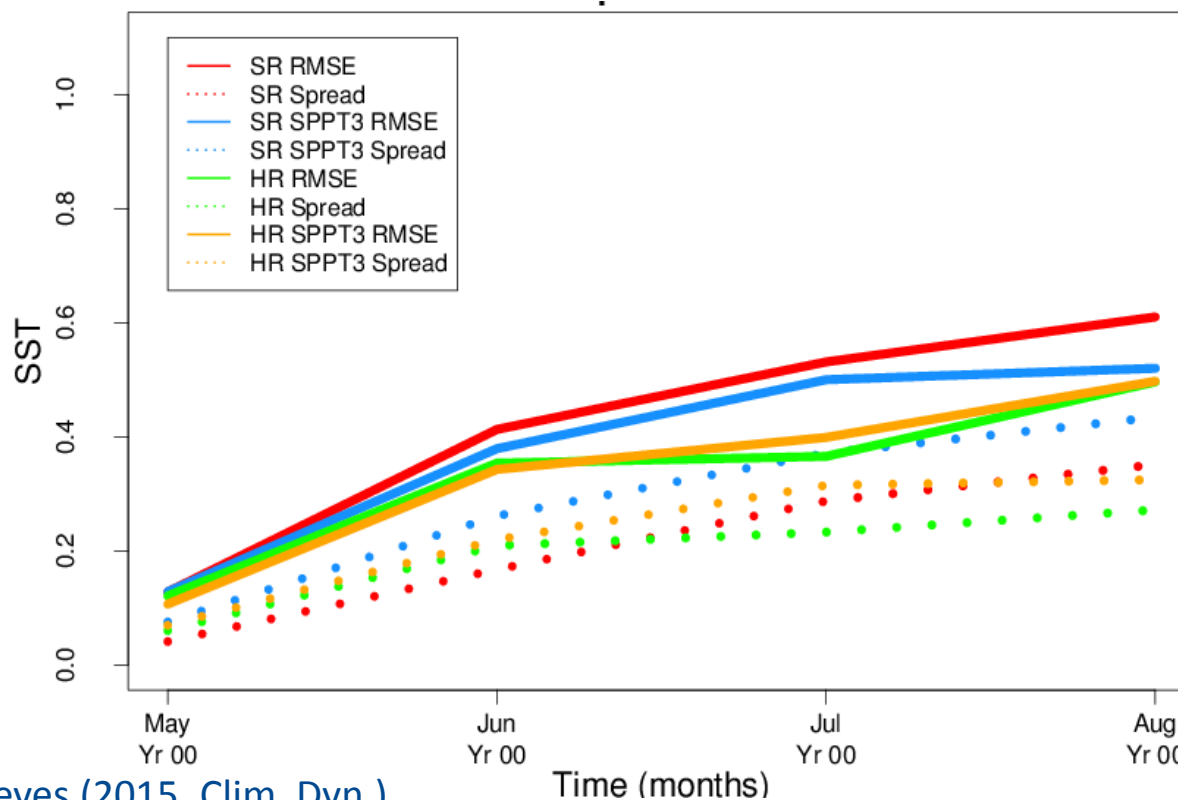
Prediction skill ENSO: Different observations

Prediction skill ENSO: Increase in resolution

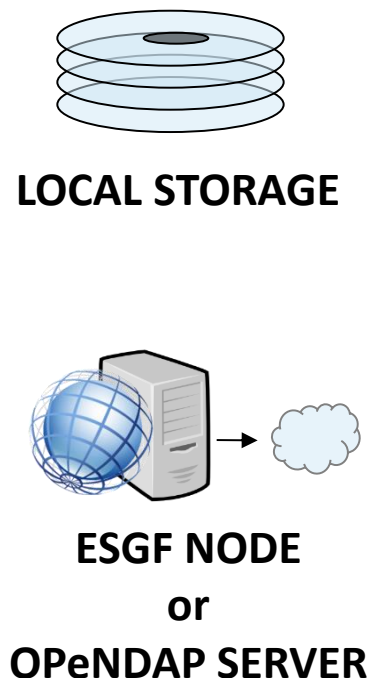


High resolution has been thoroughly tested in climate prediction mode. The same applies to the stochastic physics.

RMSE and spread of Niño3.4 SST (versus ERSST) from EC-Earth3 simulations: standard resolution (**SR, T255/ORCA1**), high resolution (**HR, T511/ORCA025**) without and with **stochastic physics (SPPT3)**. May start dates over 1993-2009 using ERA-Interim and GLORYS and ten-member ensembles.



S2dverification is an R package to verify seasonal to decadal forecasts by comparing experimental data with observational data. It allows analysing data available either locally or remotely. It can also be used online as the model runs.



- Supports datasets stored locally or in ESGF (OPeNDAP) servers.
- Exploits multi-core capabilities
- Collects observational and experimental datasets stored in multiple conventions:
 - NetCDF3, NetCDF4
 - File per member, file per starting date, single file, ...
 - Supports specific folder and file naming conventions.

s2dverification package

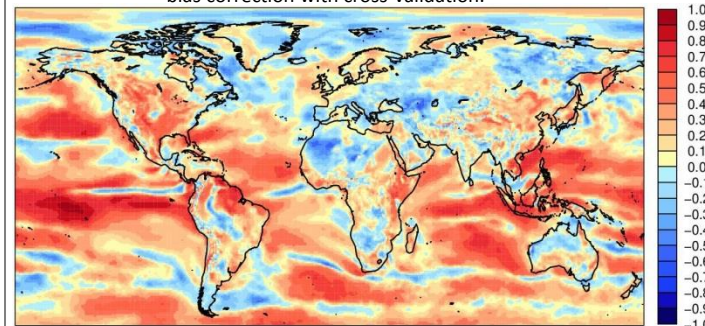
BASIC STATISTICS

SCORES

Correlation, ACC, RMSSS, CRPS, ...

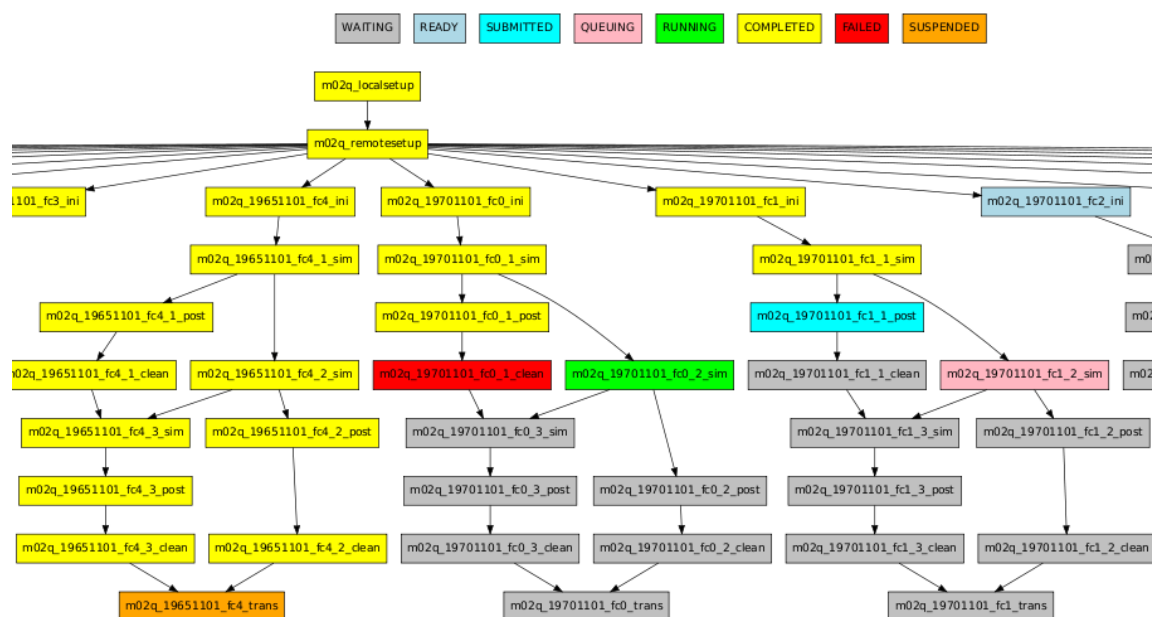
PLOTS

Anomaly Correlation Coefficient. 10M Wind Speed ECMWF S4 1 month lead with start dates once a year on first of November and Era-Interim in DJF from 1981 to 2011. Simple bias correction with cross-validation.

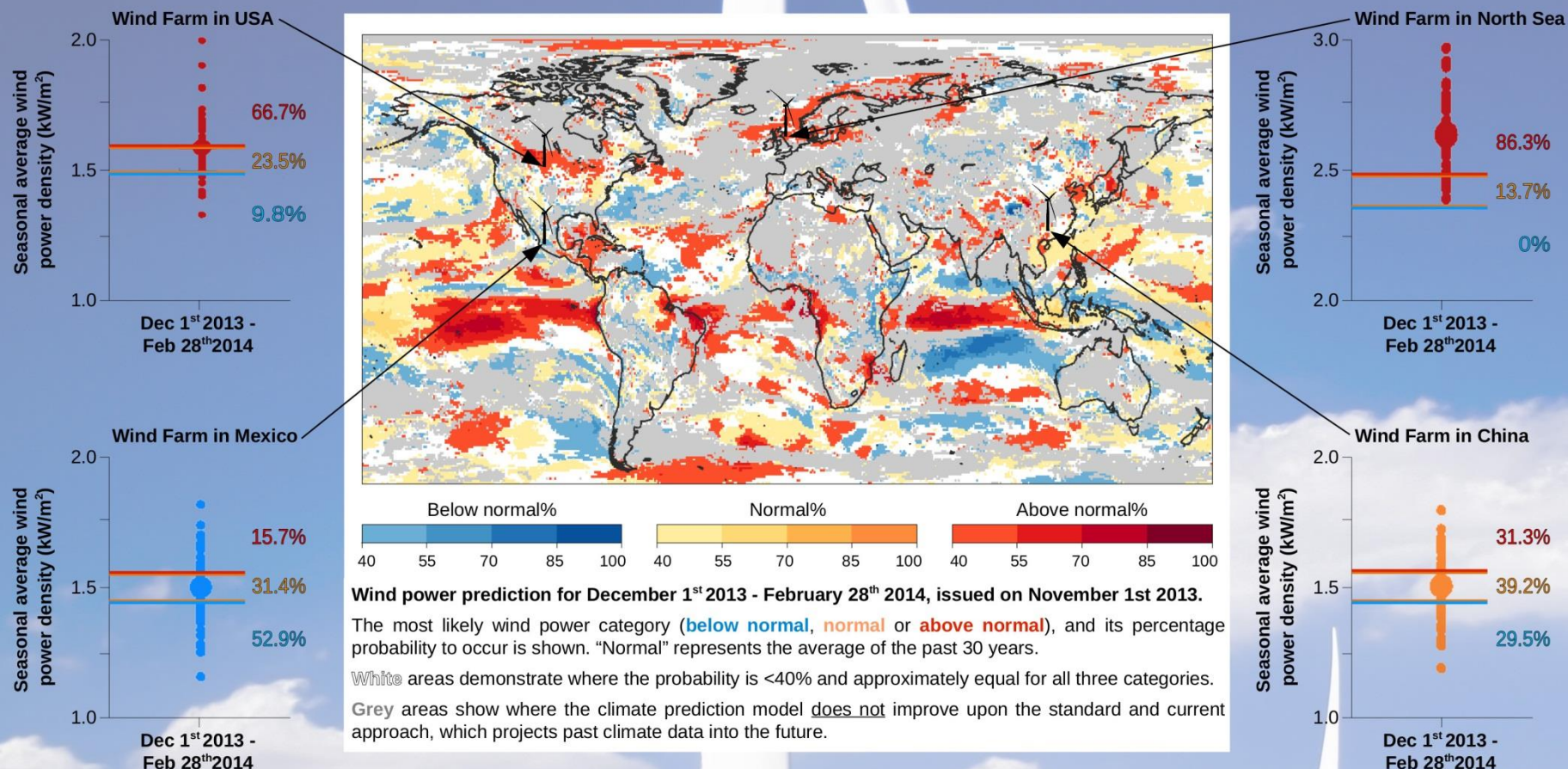


- **Automatisation:** Preparing and running, postprocessing and output transfer, all managed by Autosubmit. No user intervention needed.
- **Provenance:** Assigns unique identifiers to each experiment and stores information about model version, configuration options, etc
- **Failure tolerance:** Automatic retrials and ability to repeat tasks in case of corrupted or missing data.
- **Versatility:** Currently runs EC-Earth, Also NEMO, WRF and NMMB models.

Workflow of an experiment monitored with Autosubmit (yellow = completed, green = running, red = failed, ...)



Illustrative examples of seasonal wind power predictions



- Requests for climate information for the next season comes from a **broadening range of users** and should be addressed from a climate services perspective.
- The **initialisation** of both soil moisture and sea ice **increases the forecast quality** at the regional level, and possibly also remotely.
- The **increase of model resolution** is a substantial technical challenge and requires at least resources an order of magnitude larger than currently available, but **shows clear signs that is one of the most promising ways to improve the quality of the predictions.**
- None of this will materialize without appropriate investment in **observational networks and reduction of all aspects of model error, plus infrastructures that rationalize the investments in climate-modelling research.**